SCARIFIER FOR THE INTERIOR SURFACE OF A PIPELINE

RELATED APPLICATIONS

The present application is a continuation-in-part of United States Patent Application No. 09/917,685, which is a continuation-in-part of United States Patent Application No. 09/569,880, now issued as U.S. Patent No. 6,418,947, which is a division of Application No. 09/126,113 filed on July 30, 1998, now Pat. No. 6,206,016.

FIELD OF THE INVENTION

The present invention relates to a device for scarifying the interior surface of a pipe and more specifically for profiling the interior surface of a sewer pipe and for cleaning off any corrosion or contaminates from the surface thereof.

BACKGROUND OF THE INVENTION

Pipes used to carry liquids and gases commonly transport all types of materials including water, natural gas, solid and liquid sewage, as well as various other accumulations from the pipe. Currently, during initial

installation, sewer pipes must be scarified first in order to provide a clean and profiled surface for the subsequent coating with such materials as polyvinyl chloride sheet. Older sewer pipes eventually need to be scarified to remove contamination, corrosion and loose material. The term "scarify" is intended to mean a removal of a layer or portion of the interior surface of the pipe whether or not it is contaminated or corroded in order to provide a profile to that surface. The term "profile" refers to a surface having peaks and valleys giving it a granulated texture similar to that of sandpaper. Such a surface provides a greater surface area so as to maximize bonding of the coating material. Profiled surfaces can range from fine-grained similar to the granularity of #150 Fine Sandpaper to a coarse-grained similar to the granularity of #60 Coarse Sandpaper.

The interior surface of a pipeline carrying solids, liquids and gases generally degrades over time as the pipe walls interact chemically and physically with the substances flowing through them. In particular, a sewer system's interior walls corrode and deteriorate because corrosive materials contaminate the surface degrading the metal and concrete used to build the sewer. The corrosive material

arises from both the sewage and from the wastewater itself, and also from the digestive by-products of bacteria found in the sewage, which proliferate in the anaerobic environment. The corrosion causes the walls of the sewer pipe to physically decay, eventually reducing their overall thickness.

The principal source of corrosion is sulfuric acid, which arises as a product of the materials transported in a sewer pipe and the sewer environment itself. Various metal sulfates found in the sewage quickly convert into hydrogen sulfide by: reducing to sulfide ions in the waste water, combining with hydrogen in the water and out gassing above the liquid as hydrogen sulfide gas. Additional hydrogen sulfide originates from bacteria containing contaminants, which accumulate on the relatively rough concrete below the maximum liquid level. Bacteria found in these accumulations thrive in the anaerobic sewer environment producing hydrogen sulfide gas as a respiratory bi-product. Oxygen from the liquid below and oxygen condensing from the water in the air react with the hydrogen sulfide on the pipeline walls creating the highly corrosive sulfuric acid. The sulfuric acid attacks the calcium hydroxide in the concrete sewer walls leaving calcium sulfates, which ultimately crumble and

fall off of the interior of the wall substantially reducing its thickness.

The waste water level in a sewer varies over the course of a 24-hour period. The flow is at its lowest level between 1:00 AM and 6:00 AM in the morning but it rises distinctly in the daytime and the pipe may operate near capacity. Because of the gaseous nature of the hydrogen sulfide, the pipe walls are predominately corroded in the portions of the wall above the minimum liquid level. Portions of the walls which are always below the water level are not subjected to such high concentrations of hydrogen sulfide gas or sulfuric acid and consequently do not experience the same levels of decay.

Eventually the sewer walls must be restored or they can suffer permanent damage leading to great expense. The restoration process is a two-step operation that consists of first cleaning all of the contaminants (and possibly outer layers of corrupted concrete) from the surface of the pipe and then applying a protective coating over the newly cleaned pipe surface. Attempting to apply a protective coating without first cleaning the pipe surface is futile because it does not stop the decay that has already begun

underneath the coating. Furthermore, the protective coating itself does not adhere well to the contaminated surface. Thus, cleaning is an essential element of the restoration process. Even new sewer pipe must be scarified to provide a profiled surface and to remove the laitance and any dirt, oil or grease.

As previously mentioned, a sewer system typically operates at high capacity during the day with decreasing flow overnight. In order to restore the sewer pipes without diverting the flow (a costly and sometimes impossible alternative), a bulk of the work must be done at night during the brief period when the flow is at a minimum. As previously outlined, the restoration process involves both profiling the pipe surface and then applying a protective coat. In practice, the rate of restoration is impaired because manual scarifying (i.e., grinding) takes a proportionally greater amount of time than does the application of the protective coat. Consequently, a need exists for an automated scarifying process. Such a process will improve the rate of cleaning of the pipeline's interior walls making restoration without diversion a cost-effective possibility. Further, automation of the process can help to ensure that the same intensity of cleaning is applied to the

entire surface without the quality variation that is inherent in manual execution.

SUMMARY OF THE INVENTION

According to the invention there is provided an apparatus for scarifying an interior surface of a sewer pipe, which includes a vehicle moveable along an interior of the pipe and a fluid nozzle assembly connected to the vehicle. The fluid nozzle assembly has at least one branch with a fluid nozzle coupled to a distal end of the branch. The nozzle is positioned proximate the interior surface of the pipe. The fluid nozzle assembly is operative to rotate or oscillate and to emit a jet of fluid from the nozzle against the interior surface of the passageway and to scarify the interior surface of the passageway as the vehicle moves along the sewer pipe.

The one branch may be extendible. Making the one branch replaceable with a branch of a different length may provide the extendibility. Alternatively, making the one branch in sections and adding or removing one or more sections may provide the extendibility of the one branch.

Preferably the one branch is coupled to an exchanger, which couples fluid to the one branch and rotates or oscillates.

Advantageously, the one branch has a counterweight coupled to the exchanger.

The counterweight may be a non-fluid conducting branch extending out from the exchanger on a side opposite to the one branch.

Preferably, there are a plurality of branches extending radially from said exchanger, said branches spaced so that each branch is counterbalanced by one or more other branches of the plurality of branches.

Advantageously, each branch of the plurality of branches is extendible and each branch has a fluid nozzle coupled to a distal end thereof.

Each branch of the plurality of branches is extendible by being replaceable with a branch of another length or alternatively by adding or removing sections of each branch.

The vehicle comprises a chassis operative to support the apparatus, the chassis being adjustable to accommodate various pipe sizes and having a track assembly operative upon rotation to propel the vehicle along a longitudinal direction in the interior of the pipe. A motor, mounted on the chassis and coupled to the track assembly, is operative to rotate the track assembly. A power coupler, mounted on the chassis and couplable to a power source, conducts power to the apparatus.

The vehicle may comprise a chassis, which may be adjustable to fit various pipe sizes and may support the apparatus, a track assembly which may propel the vehicle along a longitudinal direction of the pipe as it rotates. A motor mounted on the apparatus may drive the track assembly and a power coupler mounted on the chassis may conduct power to the apparatus. The power source may be any type of power, but preferably, the source may be electric or hydraulic. Advantageously, the power source may be located on-board the apparatus or may be at an off-board location remote from the vehicle.

Advantageously, the vehicle may be equipped with guiding bars affixed to the chassis at one end and having

wall engaging attachments, which move along the interior surface of the pipe and maintain the orientation of the vehicle along a longitudinal axis of the pipe. Preferably the guiding bars are adjustable so as to extend from the vehicle to the interior surface of the pipe.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing advantages and novel features of the invention will be more fully apparent from the following description when read in connection with the accompanying drawings in which:

FIG. **1** is a side view of the first embodiment showing the vehicle and the scarifying system consisting of the arm and the fluid nozzle assembly;

FIG. **2** is a front view of the first embodiment showing the arm in a vertical orientation;

FIG. **3** is a top view of the first embodiment showing the principal arm in a vertical orientation;

FIG. **4** is a front view of the first embodiment showing the arm extended at a radial angle to reach the interior surface of the pipe;

FIG. **5** is a side view of a second embodiment of the invention depicting an arm mounted vertically on the front of a vehicle and branches of a fluid nozzle assembly pointing radially at an interior surface of a pipe;

FIG. **6** is a front view of the second embodiment of FIG. **5**;

FIG. **7** is a top view of the second embodiment of the invention;

FIG. **8** is a top view of a nozzle assembly used in the scarifier;

FIG. **9** is a side elevation view of the nozzle assembly used in the scarifier;

FIG. **10** is a side view of a third embodiment of the invention depicting a principal arm and subsidiary arms each having a fluid nozzle assembly;

FIG. **11** is a front view of a third embodiment of the invention depicting a principal arm and subsidiary arms, each subsidiary arm having a fluid nozzle assembly;

FIG. **12** is a top view of a third embodiment of the invention;

FIG. **13** depicts a swath of an interior surface of a pipe scarified by a first embodiment of the invention;

FIG. **14** is a side view of a fourth embodiment of the invention employed for scarifying a bottom surface of a pipe;

FIG. **15** is a front view of the fourth embodiment fo the invention;

FIG. **16** is a top view of the fourth embodiment of the invention; and

FIG. **17** is a perspective view of an alternative embodiment of the nozzle assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Embodiments of this invention are outlined below with reference to the drawings.

The First Embodiment

The first embodiment of the apparatus for scarifying the interior surface of a pipeline is depicted in Figures **1-4**. Figures **1-3** depict side, front and top views, respectively, of the first embodiment with the arm **7** oriented in a vertical position. Figure **4** depicts a front view of the apparatus with the arm **7** at a transverse angle. The nozzle assembly **10** of the first embodiment is depicted in Figures **8** and **9**.

The apparatus comprises a vehicle **18** that is propelled along a longitudinal direction inside of a pipe, cleaning the interior surface as it travels. The apparatus is equipped with a scarifying system **19** comprising an arm **7** and a nozzle assembly **10**. The scarifying system **19** extends from the vehicle to the wall of the conduit and uses nozzles to clean and scarify the interior surface of the pipe.

The vehicle **18** includes a chassis **2,** which moves longitudinally along the bottom floor of the pipe on its track assembly **1**. The tracks **1** are propelled along rollers **3** by a hydraulic motor (not shown) sitting on board the chassis **2**. The hydraulic motor is powered by an external hydraulic reservoir (not shown) coupled to the apparatus by a hydraulic coupler (not shown) also mounted on the chassis **2**. It will be noted that, although a hydraulic motor is used in this embodiment, any power providing means, both external or on-board but preferably exhaustless, may be used for this application. Alternatively, with a sufficiently light vehicle, the vehicle could also be moved manually. The direction of motion of the vehicle is that of arrow **16** or **17**. An on-board battery **4** powers hydraulic switches (not shown), which control the speed and direction of motion of the vehicle. The motor, hydraulic coupler and hydraulic switches are covered with plate **5** to protect their sensitive parts from debris dislodged during cleaning. When nozzles **15** are employed to clean and/or scarify the walls of the conduit, recoil forces may tend to disturb the vehicle trajectory. Accordingly, a number of guiding bars **20** may be attached to the chassis **2** of the vehicle **18** and telescopically extend to the walls of the pipeline. The guiding bars' wall engaging attachments **21** move along the

pipe's walls and prevent the vehicle **18** from deviating from its path.

The scarifying system **19** consists of a telescoping arm **7** and a fluid nozzle assembly **10**. The arm **7** includes two telescoping pipes in which the upper portion of the pipe **12** has a smaller diameter such that it slides down into the lower portion. The piston **26** controls the extension of the telescoping arm **7**. This combination of telescoping parts permits the arm **7** to be extended or contracted depending on the diameter of the pipe surface to be cleaned. The arm **7** pivots on hinge **25** in a lateral direction so that it can reach any transverse angle between 0° and 180°. Consequently, the device can manipulate the scarifying system **19** so that the fluid nozzle assembly **10** is in close proximity to the pipe walls. Since this embodiment contains only one arm **7**, a stabilizing bar **8** is used to counteract the weight of the arm **7** as it is extended radially.

The scarifying system **19** may be easily removed from the chassis **2** of the vehicle **18** in order to reduce the size of the apparatus so as to enter a sewer system through a small aperture such as a manhole. Furthermore, the width of the chassis **2** (i.e. separation between tracks **1**) can be

adjusted so as to position the vehicle **18** longitudinally in pipes of various sizes.

The fluid nozzle assembly **10** is mounted at the distal end of the arm's **7** telescoping pipes. Fluid coupler **9** with a flow control valve is attached to an external source of fluid under pressure (not shown), which is fed into exchanger/actuator **13**. Referring to Figure **8**, exchanger/actuator **13** causes the fluid nozzle assembly **10** to rotate or oscillate and distributes the fluid to each branch **14** of the fluid nozzle assembly **10**. Arrows 22 and 23 indicate the direction of rotation. The actual fluid nozzles **15** emit jets of fluid aimed against the pipeline walls. The fluid nozzles **15** discharge fluid to profile and clean the interior surface of the pipe. The drawings show one fluid nozzle **15** attached to each branch **14**, but it should be obvious to one skilled in the art that a plurality of nozzles **15** may be coupled to each branch **14**.

Referring now to Figures **4** and **13**, as the vehicle **18** travels up the center of the pipe floor **27**, the scarifying system **19** scarifies a swath of the pipe wall **28**. The swath is approximately the same width **29** as the diameter of the fluid nozzle assembly **10** and is centered approximately at

the arm angle **30**. Fully scarifying the interior surface of the pipe requires that the vehicle **18** make several passes back and forth, changing the arm angle **30** with each pass. The vehicle chassis is outfitted with a drawbar (not shown), which holds the hydraulic and pressurized fluid tethers away from the apparatus so that it may easily travel forward or reverse without running over the tethers.

An additional safety feature not shown in the drawings is a "deadman" which is a safety switch operative to cut off the high pressure from the moving parts of the scarifying system **19**. The deadman is useful in both emergency situations and when minor adjustments must be made to the apparatus during a job.

This apparatus is the preferred embodiment when the conduits or pipes are not perfectly cylindrical in shape (i.e. they are some other shape such as semicircular in cross section). This embodiment can also be used for a cylindrical pipe when flow diversion is impossible. A false floor **31** is layered on top of the minimum flow mark **32** and the cleaning is performed above the false floor **31**. Since most of the corrosion occurs in levels above the minimum

liquid level **32**, this cleaning method is acceptable for restoration applications.

The Second Embodiment

The second embodiment for scarifying the interior surface of a pipeline is depicted in Figures **5-7**. The figures depict side, front and top views respectively of the second embodiment with the arm **7** mounted on the front of the vehicle.

As with the first embodiment, the apparatus comprises a vehicle **18** that propels itself along a longitudinal direction inside of a pipe, scarifying the interior surface as it travels. The apparatus is equipped with a scarifying system **19** including an arm **7** and a fluid nozzle assembly **10**. The scarifying system **19** extends from the vehicle **18** to the wall of the conduit and uses fluid nozzles **15** to clean and/or profile the interior surface of the pipe.

The vehicle **18** is the same as the first embodiment and includes a chassis **2,** which moves longitudinally along the bottom of the pipe floor on its track assembly **1**. The

tracks **1** are propelled along rollers **3** by a hydraulic motor (not shown) sitting on board the chassis **2**. Although tracks **1** are included in this description of the preferred embodiment, any system capable of moving the vehicle **18** under power from the hydraulic motor will suffice. Alternatively, if the vehicle is made sufficiently light, it may be moved manually.

The hydraulic motor is powered by an external hydraulic reservoir (not shown) coupled to the apparatus by a hydraulic coupler (not shown) also mounted on the chassis **2**. It will be noted that, although a hydraulic motor is used in this embodiment, that any power providing means, both external and on-board but preferably exhaustless, may be used for this application. The direction of motion of the vehicle **18** is that of arrow **16** or **17**. An on-board battery **4** powers hydraulic switches (not shown), which control the speed and direction of motion of the vehicle. The motor, hydraulic coupler and hydraulic switches are covered with plate **5** to protect their sensitive parts from debris dislodged during cleaning.

When fluid nozzles **15** are employed to clean the walls of the conduit, recoil forces may tend to disturb the

vehicle trajectory. Accordingly, a number of guiding bars **20** may be attached to the chassis **2** of the vehicle **18** and telescopically extend to the walls of the pipeline. The guiding bars' wall engaging attachments, **21** move along the pipe's walls and prevent the vehicle **18** from deviating from its path. Once again, the vehicle **18** may be adjusted in width by adjusting the chassis **2**, so as to position the vehicle **18** longitudinally in pipes of various sizes. Similarly to the first embodiment, the vehicle chassis **2** is equipped with a drawbar (not shown) to hold the hydraulic and high pressure fluid tethers away from the vehicle **18**.

In the second embodiment, the scarifying system **19** consists of a vertical arm **7** attached to the front of the chassis **2** and a fluid nozzle assembly **10**. The entire scarifying system **19** may be easily removed from the chassis **2** of the vehicle **18** in order to reduce the size of the apparatus so as to enter a sewer system through a small aperture such as a manhole. In fact, the width of the tracks may be narrowed for the same reason and, after entering the sewer pipe, the tracks may be widened to a desired width. The arm **7** includes adjusters **6** which raise the fluid coupler **9** at the center of the fluid nozzle assembly **10** to align it roughly with the center of the pipe.

This alignment permits even spray on all portions of the pipeline walls. The arm **7** has a stabilizing bar **8,** which helps to counteract the weight of the arm **7** in front of the vehicle **18**.

The fluid nozzle assembly **10** attaches to the vertical arm **7**. Fluid coupler **9** with a flow control valve is attached to an external source of fluid under pressure (not shown). The fluid is fed into exchanger/actuator **13**. Referring to Figure **6**, exchanger/actuator **13** causes the fluid nozzle assembly to rotate or oscillate and distributes the fluid to each branch **14** of the fluid nozzle assembly **10**. The branches **14** are each counterbalanced by other branches of the plurality of branches. The direction of rotation of the fluid nozzle assembly **10** is indicated by arrows **22** and **23**.

The branches **14** are laterally extendible so as to bring the fluid nozzles **15** (which are mounted on the ends of the branches **14**) into proximity with the pipeline walls and direct them at the wall's interior surface. The meaning of the term "extendible" used here is intended to include any system by which the total length of the branches can be set so that the branches and nozzles at an end thereof are

[redacted]

positioned proximate the interior wall of the sewer pipe. One type of extendibility of the branches is the replacement of branches with branches of a different length. Another scheme is providing branches, which can be telescopically lengthened. The apparatus can have only one branch **14,** which is equipped with a nozzle and a counterweight to the one branch **14.** The counterweight can be another branch **14** opposite the one branch or, obviously, it can be of any other shape as long as it counterbalances the branch **14**. The counterbalance could even be made up of two or more counterbalancing elements symmetrically disposed with respect to an axis of the branch **14**.

The fluid nozzles **15** discharge fluid to scarify the interior surface of the wall. Again it is understood as being obvious to one skilled in the art, that there may be a number of nozzles **15** for each branch **14**. Alternatively, one could block off any number of nozzles by simply inserting plugs into the branches to be closed off. In addition, the fluid nozzles **15** can be angled with respect to their branches so that they provide a torque that causes them to rotate. In its simplest form one can have one nozzle at the end of a first branch and a second branch with its fluid channel blocked off extending out 180 °C to the first branch

to act as a counterbalance to the first branch. Various other variants are possible and are obvious to an ordinary person skilled in the art.

As the vehicle **18** travels longitudinally along the center of the pipe floor in a direction indicated by arrows **16** and **17**, the scarifying system **19** scarifies a transverse circumferential line along the interior of the pipe wall. Unlike the swaths in the first embodiment, this apparatus is capable of scarifying the entire interior surface in a single pass through the pipe. However, because a significantly larger area is being cleaned, the vehicle **18** must travel slower than it does in the first embodiment ensuring adequate coverage of the walls.

This apparatus is preferred over the first embodiment when the conduits or pipes are cylindrical in shape and the entire 360° circumference of the pipe is being cleaned.

The Third Embodiment

The third embodiment is a combination of the first and second embodiments and is depicted in Figures **10-12**,

which show side, front and top views, respectively. The principal arm **7** is connected to the front of the chassis **2** as in the second embodiment, but the fluid nozzle assemblies **10** are that of the first embodiment.

The vehicle **18**, chassis **2**, motor (not shown), guiding bars **20**, guiding bar attachments **21**, battery **4**, hydraulic coupler, deadman and drawbar (not shown) are substantially the same as that of the first two embodiments. The scarifying system **19**, however, is considerably different. The principal arm **7** is oriented vertically and is essentially the same as the arm in the second embodiment, but it has a plurality of additional subsidiary arms **11** which extend transversely from the center of the principal arm **7**. The adjusters **6** move vertically to align the center of the subsidiary arms **11** with the center of the pipe. The subsidiary arms **11** are telescopically adjustable so that they can extend transversely to the inner surface of the pipeline walls. A fluid coupler **9** with flow control valve receives fluid under pressure from an external source (not shown). An exchanger/actuator **33** simultaneously rotates or oscillates the subsidiary arms **11** and distributes the fluid. At the end of each subsidiary arm **11** is a fluid nozzle assembly **10** that is basically the same as that of the first

embodiment. Each fluid nozzle assembly **10** has a secondary fluid coupler **24**, an exchanger/actuator **13**, symmetrical branches **14**, and fluid nozzles **15**.

The vehicle **18** travels longitudinally along the center of the pipe in a direction indicated by arrows **16** or **17**, while the subsidiary arms **11** rotate or oscillate in the direction of arrow **22** or **23**, moving the fluid nozzle assemblies **10** laterally across the inner circumference of the pipeline wall. The fluid nozzle assemblies **10** are simultaneously rotating or oscillating such that they are cleaning a swath similar to the first embodiment, but the swath is laterally oriented.

The third embodiment (like the second) is most useful for cleaning the entire circumference of the interior of a cylindrical pipe. However, the wide swath enabled by incorporating the fluid nozzle assembly **10** from the first embodiment permits the vehicle **18** to travel faster down the pipeline floor and still maintain adequate coverage of the walls.

The Fourth Embodiment

The fourth embodiment is also a combination of the first and second embodiments, which is particularly adapted to clean the bottom surfaces of pipelines. The fourth embodiment is depicted in Figures **14-16**, which show side, front and top views respectively. The principal arm **7** is connected to the front of the chassis **2** as in the second embodiment but the fluid nozzle assembly **10** is that of the first.

The vehicle **18**, chassis **2**, motor (not shown), guiding bars **20**, guiding bar attachments **21**, battery **4**, hydraulic coupler, deadman and drawbar (not shown) are substantially the same as those of the first two embodiments. The scarifying system **19**, however, is considerably different. The principal arm **7** is oriented vertically and is essentially the same as the arm in the second embodiment, but it has an additional subsidiary arm **11**, which extends forwardly from the principal arm **7**. The adjusters **6** move vertically up the principal arm **7** to adjust the height of the subsidiary arm **11**. The subsidiary arm **11** holds the fluid nozzle assembly **10**, and the fluid coupler **9** with flow control valve which are basically the same

elements as in the first embodiment. The fluid nozzle assembly **10** is outfitted with an exchanger actuator **13**, symmetrical branches **14**, and fluid nozzles **15**. Note: these elements are shown in Figures **8** and **9**. A stabilizing bar **8** extends from the front end of the subsidiary arm **11** to the top end of the principal arm **7** to help stabilize the front of the apparatus when it is carrying the additional weight of the fluid nozzle assembly **10**.

As the vehicle **18** travels longitudinally along the center of the pipe floor in a direction indicated by arrows **16** and **17**, the cleaning system **19** cleans a transverse circumferential line along the interior of the pipe wall. Unlike the swaths in the first embodiment, this apparatus is capable of cleaning the entire interior surface in a single pass through the pipe. However, because a significantly larger area is being cleaned, the vehicle **18** must travel more slowly than it does in the first embodiment ensuring adequate coverage of the walls.

An additional safety feature not shown in the drawings is a "deadman" which is a safety switch operative to cut off the high pressure from the moving parts of the cleaning system **19**. The deadman is useful in both emergency

situations and when minor adjustments must be made to the apparatus during a job.

This apparatus is preferred over the first embodiment when the conduits or pipes are cylindrical in shape and the entire 360° circumference of the pipe is being cleaned.

The Third Embodiment

The third embodiment is a combination of the first and second embodiments and is depicted in Figures **10-12**, which show side, front and top views, respectively. The principal arm **7** is connected to the front of the chassis **2** as in the second embodiment, but the spray nozzle assemblies **10** are that of the first.

The vehicle **18**, chassis **2**, motor (not shown), guiding bars **20**, guiding bar attachments **21**, battery **4**, hydraulic coupler, deadman and drawbar (not shown) are substantially the same as that of the first two embodiments. The cleaning system **19**, however, is considerably different. The principal arm **7** is oriented vertically and is essentially the same as the arm in the second embodiment,

but it has a plurality of additional subsidiary arms **11** which extend transversely from the center of the principal arm **7**. The adjusters **6** move vertically to align the center of the subsidiary arms **11** with the center of the pipe. The subsidiary arms **11** are telescopically adjustable so that they can extend transversely to the inner surface of the pipeline walls. A fluid coupler **9** with flow control valve receives fluid under pressure from an external source (not shown). An exchanger/actuator **33** simultaneously rotates or oscillates the subsidiary arms **11** and distributes the fluid. At the end of each subsidiary arm **11** is a nozzle assembly **10** that is basically the same as that of the first embodiment. Each nozzle assembly **10** has a secondary fluid coupler **24**, an exchanger/actuator **13**, symmetrical branches **14**, and spray nozzles **15**.

The vehicle **18** travels longitudinally along the center of the pipe in a direction indicated by arrows **16** or **17**, while the subsidiary arms **11** rotate or oscillate in the direction of arrow **22** or **23**, moving the spray nozzle assemblies **10** laterally across the inner circumference of the pipeline wall. The spray nozzle assemblies **10** are simultaneously rotating or oscillating such that they are

cleaning a swath similar to the first embodiment, but the swath is laterally oriented.

The third embodiment (like the second) is most useful for cleaning the entire circumference of the interior of a cylindrical pipe. However, the wide swath enabled by incorporating the nozzle assembly **10** from the first embodiment permits the vehicle **18** to travel faster down the pipeline floor and still maintain adequate coverage of the walls.

The Fourth Embodiment

The fourth embodiment is also a combination of the first and second embodiments, which is particularly adapted to clean the bottom surfaces of pipelines. The fourth embodiment is depicted in Figures **14-16**, which show side, front and top views respectively. The principal arm **7** is connected to the front of the chassis **2** as in the second embodiment but the nozzle assembly **10** is that of the first.

The vehicle **19**, chassis **2**, motor (not shown), guiding bars **20**, guiding bar attachments **21**, battery **4**, hydraulic coupler, deadman and drawbar (not shown) are

substantially the same as those of the first two embodiments. The cleaning system **18**, however, is considerably different. The principal arm **7** is oriented vertically and is essentially the same as the arm in the second embodiment, but it has an additional subsidiary arm **11**, which extends horizontally from the principal arm **7**. The adjusters **6** move vertically up the principal arm **7** to adjust the height of the subsidiary arm **11**. The subsidiary arm **11** holds the fluid nozzle assembly **10**, and the fluid coupler **9** with flow control valve which are basically the same elements as in the first embodiment. The fluid nozzle assembly **10** is outfitted with an exchanger actuator **13**, symmetrical branches **14**, and fluid nozzles **15**. Note: these elements are shown in Figures **8** and **9**. A stabilizing bar **8** extends from the front end of the subsidiary arm **11** to the top end of the principal arm **7** to help stabilize the front of the apparatus when it is carrying the additional weight of the nozzle assembly **10**.

The vehicle **18** travels longitudinally along the center of the pipe in a direction indicated by arrows **16** or **17**, while the branches **14** of the nozzle assembly **10** rotate or oscillate, moving the spray nozzles **15** around on the bottom surface of the pipeline. The spray nozzles cut a

swath similar to the first embodiment except that the swath is on the bottom surface of the pipe rather than at a radial angle. The fourth embodiment is specifically suited for cleaning the bottom surface of a pipeline.

Referring to Fig. **17**, the nozzle assembly **36** comprises a single oscillating arm or branch **42** having a nozzle **44** at a distal end and coupled at another end to a motor assembly (not shown) contained within a chassis **38**. A high pressure water hose **46** couples to the branch within the chassis **38** and an electrical cable **48** couples to the motor assembly (not shown). The chassis **38** is mounted on a moveable vehicle **40** that carries it along an interior of a pipe. The length of the arm or branch **42** is selected so that the nozzle **44** is proximate an interior surface of the pipe to be scarified.

In operation, the vehicle **40** is indexed from one position to the next and at each position the arm makes a complete sweep from one side to the next. In order to cover a wider area, the nozzle **44** could be made to rotate about an axis at an angle to its own axis. Alternatively, a nozzle assembly with one or more nozzles rotating about an axis through the arm **42** could be employed. In order to cover a

maximum of pipe wall area, the chassis **38** has to be mounted as close to the bottom of the pipe as possible.

Accordingly, while this invention has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications of the illustrative embodiments, as well as other embodiments of the invention, will be apparent to persons skilled in the art upon reference to this description. It is therefore contemplated that the appended claims will cover any such modifications or embodiments as fall within the true scope of the invention.